TDP (Honours) 5th Semester Exam., 2019

PHYSICS

(Honours)

TWELFTH PAPER (CC-12)

Full Marks : 60 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Section - A

1. Answer any *six* of the following questions : 2×6=12

   (a) What do you mean by Brillion zones?

   (b) Explain the concept of reciprocal lattice.

   (c) Define Debye's T^3 law.

   (d) What is the evidence for existence of Phonon?

   (e) Why is the Hall coefficient positive in some metals?

[Turn Over]

(f) What do you mean by Meissner effect?

(g) On the basis of Weiss theory of ferromagnetism how will you explain Curie point?

(h) How do you establish the existence of ferroelectricity in a material?

Section - B

Answer any *four* questions : 12×4=48

2. (a) (i) Derive Bragg's law in x-ray diffraction.

(ii) Find the Miller indices of a set of parallel planes which make intercepts in the ratio $3a : 4b$ on the x and y axes and are parallel to z axis, a, b, c being primitive vectors of the lattice. Explain the importance of Miller indices.

(iii) How the reciprocal lattice vector is related to direct lattice vector?

(iv) Determine the atomic packing fraction of a f.c.c crystal structure. 3+(3+2)+2+2

Or,

(b) (i) Describe powder method of x-ray diffraction. Discuss the formation of

diffraction pattern on the photographic film and its utility.

(ii) Explain the origin of metallic and molecular bonding in crystals with suitable examples.

(iii) How are atomic scattering factor and geometrical structure factor related? (3+2+2)+(2+2)+1

3. (a) (i) Derive the vibrational modes of a diatomic linear lattice. Name the different branches of the dispersion relation curve. What is the difference between these two branches?

(ii) Write the drawbacks of Debye model.

(iii) What is phonon? Write the properties of phonon. What is the difference between photons and phonons? (3+1+2)+2+(1+2+1)

Or,

(b) (i) Derive an expression for the specific heat of solid on the Einstein model and show that at low temperatures it drops exponentially with decreasing temperature.

(ii) Calculate the Debye specific heat of copper at 10k and 300k, given that the Debye characteristic frequency is 6.55×10^{12} Hz.

(iii) Discuss the reasons for the failure of Dulong and Petit's law to predict the specific heat at low temperatures.

(iv) Explain Wiedemann-Franz law. What is drift velocity of free electrons in metals?

(3+2)+2+2+(2+1)

4. (a) (i) Discuss the Kronig-Penny model for the motion of an electron in a periodic potential. Show from (E-K) graph that materials can be classified into conductors, insulators and semiconductors.

(ii) Give an elementary theory of Hall effect.

(iii) Show that the Hall coefficient is independent of the applied magnetic field and is inversely proportional to the current density and electronic charge. (4+2)+3+3

Or,

(b) (i) What is a superconductor? How do their properties differ from those of normal conductors?

(ii) Give a qualitative description of the BCS theory.

(iii) Explain the term critical magnetic field in a superconductor. How does the critical magnetic field vary with temperature in Type I and Type-II superconductors.

(iv) Calculate the value of London penetration depth λ_0 at 0 k for lead whose density is 11.3×10^3 kg/m^3 and the atomic weight is 207.19. Its T_c is 7.22 k. (1+2)+3+(1+2)+3

5. (a) (i) What is paramagnetism? Obtain Langevin's formula for paramagnetic susceptibility.

(ii) State the criteria for ferromagnetism according to Weiss theory.

(iii) Describe the phenomenon of hysteresis in ferromagnets. Explain the usefulness of B-H curves.

(iv) Explain physically the existence of domains in a ferromagnetic material. (1+3)+2+(2+2)+2

Or,

[Turn Over]

(b) (i) Obtain an expression for Lorentz field in a dielectric material and hence derive the Clausius-Mosotti equation.

(ii) Explain electronic polarization in atoms and obtain an expression for electronic polarizability in terms of the radius of atom.

(iii) Name two ferroelectric materials.

(3+3)+(2+3)+1

S-5/PHSH/CC-11/19

TDP (Honours) 5th Semester Exam., 2019

PHYSICS

(Honours)

ELEVENTH PAPER (CC-11)

Full Marks : 60 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Section - A

1. Answer any *six* of the following questions : 2×6=12

   (a) Explain the meaning of stationary states in quantum mechanics.

   (b) What do you mean by a free particle?

   (c) What is the significance of zero point energy?

   (d) Plot the ground state eigenfunction of the hydrogen atom as a function of the distance *r*.

   (e) State Larmor's theorem.

[Turn Over]

(f) What is Stark effect?

(g) The magnesium atom has two 3s electrons outside filled inner shells. Find the term symbol of its ground state.

(h) Calculate Lande g factor for the terms $3^2S_{1/2}$ and $3^2P_{1/2}$.

Section - B

Answer the following questions : 12×4=48

2. (a) (i) State and prove Ehrenfest's theorem in quantum mechanics.

(ii) What is Hermitian operator?

Show that two eigenfunctions of Hermitian operator, belonging to different eigen values are orthogonal to each other.

(iii) Write an expression for the probability current density and calculate the same for the wave function $\psi = e^{ikr}/r$, where $r^2 = x^2 + y^2 + z^2$, and interpret the result.

(1+3)+(1+3)+(1+2+1)

Or,

(b) (i) Derive Heisenberg's uncertainty relation for the position and momentum variables.

(ii) Show that an electron can not exist inside the nucleus.

(iii) According to classical description, an electron moves with kinetic energy 1 keV. It corresponds to a Gaussian wave packet of width 10 nm. Find the time in which the width increases to 20 nm.

(iv) Show that $\left[\hat{x}, \hat{p}_x^n\right] = i\hbar n\hat{p}x^{n-1}$ and $\left[\hat{p}_x, x^n\right] = -i\hbar n x^{n-1}$. 3+2+3+(2+2)

3. (a) (i) What is harmonic oscillator? Establish Schrödinger's equation of a linear harmonic oscillator. Draw the wave function of ground state and first excited state it.

(ii) Explain whether the ground state wave function of a one-dimensional harmonic oscillator is an eigenfunction of the momentum operator.

[Turn Over]

(iii) Obtain an approximate analytic expression for the energy level in a square well potential ($b = 0$) when $v_0 a^2$ is slightly greater than $\pi^2\hbar^2/8m$.

(iv) Explain the significance of the various energy levels of the hydrogen atom which has only one orbital electron. 5+2+3+2

Or,

(b) (i) Write down the radial part of the time-independent Schrödinger equation for the hydrogen atom and hence find the relation between the eigen energies (E_n) and the principal quantum number (n).

(ii) Unnormalized hydrogenic 2P-state wave function for $m = 0$ is $\left(\frac{r}{a_0}\right) \exp\left(\frac{-r}{2a_0}\right)\cos\theta$. Determine the normalization constant.

(iii) Show that the most probable position of the electron of the hydrogen atom in the ground state is given by the first Bohr radius (a_0). Also calculate the probability that the electron lies in a sphere of radius R. 5+2+(3+2)

4. (a) (i) State and explain Moseley's law. Show that this law can be deduced from the modified Bohr's theory of hydrogen spectra.

(ii) How does the continuous x-ray spectrum arise? Why does it have a short wavelength limit?

(iii) Give a detailed account of the vector atom model. (3+3)+(2+2)+2

Or,

(b) (i) Describe Stern and Gerlach's experiment of studying the atomic rays in a non-homogeneous magnetic field. Discuss what the experimental results establish.

(ii) Illustrate with diagrams the zeeman splitting of sodium D_1 and D_2 lines.

(iii) What is Bohr magneton? What is it's physical significance? Calculate its value.

(iv) Find the minimum magnetic field needed for the Zeeman effect to be observed in a spectral line of 400 nm wave length when a

[Turn Over]

spectrometer whose resolution is 0.010 nm is used. (3+1)+2+3+3

5. (a) (i) State Pauli's exclusion principle and use it to find the electronic configuration of the sodium atom whose atomic number is 11.

(ii) Why is the ground state of the hydrogen atom not split into two sublevels by spin-orbit coupling?

(iii) What are the possible values of L for a system of two electrons whose orbital quantum numbers $l_1=1$ and $l_2=3$?

(iv) Find the S, L and J values that correspond to each of the following states :

$^1S_0$, $^3P_2$, $^2D_{3/2}$. (1+2)+2+1+(2+2+2)

Or,

(b) (i) Distinguish between singlet and triplet states in atoms with two outer electrons.

(ii) The lowest vibrational states of the $^{23}Na\,^{35}Cl$ molecule are 0.063 eV apart. Find the approximate force constant of this molecule.

(iii) What is Raman effect? Discuss the characteristics of Raman lines. Explain why Stokes lines are more intense than anti-Stokes lines. Indicate the importance of Raman effect. Give one practical use of Raman spectra. 2+2+(1+2+2+2+1)

S-5/PHSH/DSE-I/19

TDP (Honours) 5th Semester Exam., 2019

PHYSICS

(Honours)

PAPER - DSE - I

Full Marks : 80 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Section - A

1. Answer any *eight* of the following questions : 2×8=16

(i) Define packing fraction.

(ii) Define mass defect.

(iii) What is wave mechanical parity?

(iv) Define angular momentum of the nucleus.

(v) Write names of various models of the nucleus.

[Turn Over]

(vi) Why stable nuclei have more neutrons than protons?

(vii) What is the basic point of difference between the liquid drop model and shell model of the nucleus?

(viii) Electrons as such do not exist in the nucleus. What then is the cause of β-decay?

(ix) Write down the law of absorption of γ-rays in matter.

(x) What is meant by particle accelerator? Can we accelerate neutrons by a cyclotron?

(xi) On what factors does the range of α- particle depends?

(xii) What is Cherenkov radiation?

(xiii) What is meant by isospin?

Section - B

Answer any *four* questions : 16×4=64

2. (a) (i) Draw the binding fraction vs mass number curve. Write the significance of the curve.

(ii) Derive an expression for nuclear magnetic moment.

(iii) Derive an expression for the binding energy and mass of a nucleus in the ground state on the basis of semi-empirical mass formula of Weiz sacker explaining different terms.

(iv) Calculate the binding energy of the last neutron in the $^{209}_{82}Pb$ nucleus, using the semi-empirical mass formula.

(v) What are magic nuclei?

(2+2)+3+5+3+1=16

Or,

(b) (i) Give experimental evidences in support of shell structure of nucleons in nuclei.

(ii) State the main assumptions of the nuclear shell model and its limitations.

(iii) Write about the concept of mean field.

(iv) Write the characteristics of nuclear force.

(v) Explain the salient features of the liquid drop model and give the various assumptions made. 3+(3+2)+2+2+4=16

[Turn Over]

3. (a) (i) Derive the expression for the transmission probability in case of α-decay.

(ii) Explain neutrino hypothesis. Explain qualitatively how the hypothesis of a neutrino solves the apparent breakdown of conservation of momentum and energy in β-decay.

(iii) Write a short note on internal conversion.

(iv) Explain Geiger-Nuttall law relating to the ranges of α-particles in α-ray disintegrations and the half-value periods.

5+(2+3)+3+3=16

Or,

(b) (i) Derive Rutherford's formula and state how one can estimate the optimum radius of a nucleus from a study of α-ray scattering.

(ii) Describe different types of nuclear reaction. Write different types of conservation laws related to nuclear reactions.

(iii) What is meant by Q-value of a nuclear reaction ? Compute the Q-values of the reaction : ${}^{7}_{3}Li(p, \alpha){}^{4}_{2}He$. Take the mass of

${}^{1}_{1}H, {}^{7}_{3}Li$ and ${}^{4}_{2}He$ as 1.00814, 7.01823 and 4.00387 respectively.

(5+3)+(2+2)+(2+2)=16

4. (a) (i) Derive the expression of Bethe-Bloch formula for energy loss due to ionization in heavy charged particles.

(ii) What do you mean by Cherenkov radiation?

(iii) Describe an ionisation chamber and give some of its important uses. 6+3+(4+3)=16

Or,

(b) (i) What is Compton effect? Explain and derive an expression for Compton shift on the basis of quantum theory. Show that Compton shift in terms of wavelength is given by

$$\Delta\lambda = \frac{h}{m_0 c}(1-\cos\phi).$$

(ii) Why visible light cannot be used to demonstrate Compton effect?

(iii) An X-ray phone of initial frequency 3×10^{19} Hz collides with an electron and is scattered through 90°. Find its new frequency.

(2+7)+4+3=16

[Turn Over]

5. (a) (i) Describe the principle of working of a linear accelerator. Show that the total length of the linear accelerator is proportional to the wave length λ_1 of the radio frequency signal.

(ii) Give the working of a electron synchrotron. Distinguish between cyclotron and synchrotron.

(iii) Explain the difficulty of accelerating electrons in a cyclotron.

(iv) What is the energy to which protons can be accelerated in a cyclotron with a dee diameter of 2m and a magnetic field of flux density 0.72 Wb/m^2. Mass of proton = 1.673×10^{-27}kg. (3+3)+(3+2)+2+3=16

Or,

(b) (i) What do you mean by quarks? How many possible quarks are there? Write properties of quarks.

(ii) What are the characteristics of strong, electromagnetic and weak interactions? Give the laws of conservation for these interactions.

(iii) Is the reaction : $\bar{\pi}^- + p^+ \rightarrow \bar{\pi}^- + \pi^+ + \bar{\pi}^-$ allowed? Explain the logic of your answer.

(iv) What are strange particles? Explain clearly the meaning of strangeness.

(1+2+2)+(3+2)+(1+2)+(1½+1½)=16
